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ABSTRACT

Many papers and articles over the past few years have suggested that the coaxial cable television (CATV) cable carries sufficient bandwidth into and out of the home that it can serve almost every conceivable communications need--providing many television viewing channels; two-way data, audio and data services; the functions of the present telephone system; data and facsimile services for business; educational services; and municipal communication services. However, while these capabilities are or perhaps will soon be technologically feasible, the cost of implementing these services may be prohibitive. The main question to consider in relation to cable's unique and practical capabilities is the sorts of services that can be made to pay for themselves, given the high costs of the necessary terminal equipment for home and possible business use. Some factors which must be taken account of in approaching this problem are the potential "critical mass" problems of two-way hookups, the possibility that subscribers will not use services offered, and our lack of experience for determining how best some of the services can be provided. (Author/SH)

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WHAT BELONGS ON THE CABLE

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Many papers and articles over the past two or three years have suggested that the 300-MHz coaxial CATV cable carries sufficient bandwidth into (and out of) the home that it can serve almost every conceivable home communications need--providing as many TV viewing channels as anyone can think of a use for; two-way data, audio, and data services, and perhaps eventually taking over the functions of the present voice telephone system and augmenting it to provide full nationwide videophone service with TV bandwidth. At the same time, the cable is touted as the way to also provide data and facsimile services between businesses, video and audio interconnections between schools (and school systems), and a wide variety of municipal communications services such as police and fire networks, traffic surveillance and control, and so forth. The purpose of this paper is to examine some of the realities of this communications utopia from the standpoints of performance and cost, suggest those areas where the cable seems best suited to providing new or improved communication functions, and just as important, point out those areas where the urge to "cable-ize" may be inappropriate.

First of all, let's talk about cable capacity. It is true that the 300-MHz bandwidth of a single coaxial cable, or the 600-MHz bandwidth of two cables, can theoretically carry about as many entertainment, education, or citizen-information viewing channels into the home as anyone would probably ever want. As is well known, there are a number of complicated technical problems in trying to use every scrap of the available cable bandwidth, but these do seem to not represent a serious limitation at present, and should gradually be solved in the future as cable technology improves. The present cost increment for just increasing downstream capacity per cable to 25-30 channels is not great, but cable system costs (including frequency multiplex/demultiplex equipment) can rise quite steeply if many additional signals of various types are to be carried;

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i.e., the solution to the technical problems of adding these signals without mutual interference may be quite expensive in terms of system cost.

It is also true that through use of presently available time-division-multiplex (TDM) techniques, just a few channels used for two-way digital data services, plus possibly addressed-frame video (sometimes called "frame grabbing), can provide individualized communications services of enormous capacity for all subscribers in a system. A single one-megabit, two-way data channel (which requires no more than 4 MHz downstream and 4 MHz upstream) can, for example, drive about 4,000 printers simultaneously at 10 characters per second, at the same time accepting the same simultaneous input rate from 4,000 keyboards or other data input devices. Since every home obviously won't be receiving or sending all the time at this rate, such a data channel should easily serve 20,000-30,000 homes (or more, depending on how much access delay is permissible), each of which can also be polled at least every few seconds to see if they wish to initiate communications. If in addition, just one downstream TV channel is devoted to addressed-frame video, as many as 216,000 different text or picture frames per hour can also be transmitted, surely sufficient for the on-demand information access needs of our 20,000-30,000 homes.* These individualized services, however, do carry a high incremental capital cost for the necessary home terminal equipment. Added head-end equipment costs are nominal on a per-subscriber basis, except as the services become more sophisticated. More will be said about this later.

Where the seemingly bountiful cable capacity begins to look less bountiful is when one adds requirements for any significant number of non-TDM, dedicated, upstream or downstream TV-bandwidth channels that are for "private" use of some sort, and not for general viewing. For example, 4-15 TV channels per trunk seems a reasonable range of upstream capacity, depending upon whether one has a one- or two-cable system (this assumes that in a two-cable system about half of one cable would be used for upstream

*See for example "The Reston, Virginia, Test of the Mitre Corporation's Interactive Television System, John Volk, Report MTP-352, Mitre Corp., May, 1971. This system digitally addresses each interlace field separately and thus transmits 60 262-line images per second, each containing up to 800 alphanumeric characters.

signals). Allowing a few of these upstream channels for remote program origination use, a few each for school and municipal TV interconnections (note that these interconnections would probably be two-way and thus also need a downstream channel per upstream channel), there isn't room left for very many traffic or security surveillance camera channels (for example), or for much private TV channel usage by individual subscribers.

Carrying this last point to the extreme, the total upstream and downstream channel capacity of a tree-structured cable system is clearly insufficient to support large numbers of simultaneous, individual, two-way video conversations (i.e., videophone service). For that, a switched hub-structured cable plant (with individual subscriber lines) would be needed, organized like the telephone system. This is the cable configuration of the Rediffusion, Inc., "Dial-a-Program" CATV system,* and may certainly be cited as a potentially great advantage of that system. However, their present one-of-36 program-distribution switchgear was not designed for line-to-line switching and would have to be very greatly reorganized and augmented in order to provide the switching functions needed for many simultaneous subscriber-to-subscriber two-way connections on a dial-up basis. The cost of such switchgear would be very substantial.

Returning to the tree-structured cable, it is interesting to speculate what would have happened if cable systems of this type had been invented 100 years ago and installed before any other type of communication system. I am sure that the bottleneck represented by the finite simultaneous cable channel capacity per trunk would eventually have forced many full-time users (or potential users) off the cable and onto circuits dedicated for their own use, and many other users desiring part-time, private circuits onto a switched network of some sort. Thus, one must certainly closely examine potential "non-broadcast" cable communications functions or services that cannot be time-division multiplexed on just a few channels (in the manner discussed earlier) to see if it is technically

*"Dial-a-Program--an HF Remote-Selection Cable Television System", R.P. Gabriel, Proceedings of the IEEE, July, 1970, pp. 1016-1023.

practical (or economic) to devote the necessary cable bandwidth continuously to their needs, as opposed to services available to all subscribers. In many cases, dedicated facilities may represent a better solution for users with heavy communication needs between just a few locations--for example, if closed-circuit, inter-classroom usage between all schools in a city requires more than one full-time two-way channel, a private inter-school cable may be advisable, in addition to CATV cable tie-ins for its program and general communication services. Of course, if a given cable system does have unused operable channels, adding such functions or services up to capacity makes sense, at least for the short-term. The intent of this discourse is not to say that such services don't belong on the cable, but to point out that there are limitations in total capacity, and that the various "closed-circuit" services that one hears discussed can't all be handled without going to special cable configurations for this purpose. The question then arises as to whether these special, dedicated cable facilities should be handled by a CATV operator, or in some cases, even be interconnected with a CATV system at all.

On the other hand, it is worth re-emphasizing that the cable does have a unique, very practical capability for providing, at little cost in bandwidth, a class of communications services that can only be awkwardly handled (if at all) by existing communication systems--the simultaneous, rapid, two-way interaction between a very large number of individual subscribers and a central information processor/source. The key concept here is that the network configuration of a cable system permits the placing of all subscribers on one or more gigantic, broadband party lines on which addressed, time-division-multiplex, messages can be transmitted at very high rates. This clearly represents a new dimension in communications capability, and one which has great potential as an addition to other cable services. The main problem is: What sorts of services can be made to pay for themselves, given the high costs of the necessary terminal equipment for home and possibly business uses (and for certain services, of the associated head-end equipment and/or interconnections with other data bank systems)?

I am afraid that I have no ready answer to this question, but it may be of value to cite the factors which must be considered. First of all, I see this as a "chicken or the egg" situation. The economics of two-way communication has a serious critical mass problem, both in the number of subscribers equipped and connected for a given polling-type service (say meter reading), and also in the number of access services (banking, shopping, etc.) available to a given subscriber. (As an AT&T official was recently quoted in relation to the decision to temporarily shelve Picturephone, "It's no good if there is no one else to talk to.")* Thus two-way hook-ups and services may have to be subsidized in some way to ever get off the ground and their eventual self-supporting viability would seem to depend on the totality of a large number of different services each with modest fees, rather than a few services with high fees (a possible exception is pay TV).

Second, there is still a large human factors question in regard to the sorts of services under discussion, which are generally new services never before available. Given that a broad spectrum of possible services is set up and offered to subscribers in their "electronic fortresses", will they use them to the extent necessary for economic viability of the services? For example, even if a service such as home shopping is immensely popular as a concept, would enough subscribers pay a monthly terminal fee for the service, plus possibly a price premium on purchases due to the added sales costs for goods presentation on camera, automated order taking, and home delivery after purchase? Large-scale experiments, conducted for a substantial period of time (sufficient for novelty transients to die out), seem the only way to really shed some light on these difficult questions, and will require extensive cooperation and commitment on the part of many organizations for a given experiment.

A brief word about head-end costs for new types of individualized services. Simple polling and data store-and-forward interconnections with

*"Picturephones Shelved Due to Lack of Demand", The Washington Post, April 13, 1972.

other computerized data services (banks, stores, reservation systems, etc.) can be handled by a small computer with a capital cost of only a few tens of dollars per subscriber. Similarly, the head-end could forward subscriber requests for addressed-frame video signals originating elsewhere (say in a library) and put the signals on the cable at little cost in head-end equipment. However, if the cable operator wishes to provide digital data bank, data processing, or video frame services himself, his head-end costs could go up by an order of magnitude or more, depending on the services provided (rapid-access memory devices of all types tend to be very expensive). Only time and experience will show how some of these services can best be provided (assuming that there is a real market for them).

This discussion has been deliberately couched in rather general terms, without attempting to predict costs for this and that out to the penny for some future period. Many such predictions are available, and the author has previously made some of his own.* What seemed more valuable for the present purposes was an exposition, from a communications systems viewpoint, of what types of services the cable seems best at, and of what other services it could provide, but with performance difficulties or at high cost. It is hoped that this has proved useful.

*Appendix A, "On the Cable--The Television of Abundance", Sloan Commission on Cable Communication, McGraw-Hill Book Co., December, 1971.